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HOUSEHOLD BEHAVIOR AND ENERGY USE

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In the Netherlands, about 75 percent of the energy consumed in the domestic sector is used for home heating, while about 15 percent is used for water heating and 10 percent for appliances and lighting. The home heating area offers great potential both for consumers to save money and for society as a whole to save resources. Consumer travel and transport is another major area for potential savings.

Large differences are observed between households in the amount of energy they use for home heating. Seligman, Darley, and Becker (1978) found differences of 100 percent between identical homes and observed drastic changes in energy use when another family occupied a home. These large differences are related to the behavior, activities, and lifestyle of the household members. The number of household appliances, their usage intensity, thermostat settings during the day and night, and the use of ventilation systems all contribute to energy use in the home.

This study investigates usage-related household behavior and its impact on energy use. Energy-related attitudes, socio-demographic variables, and home characteristics are also included to explain the use of natural gas for home heating.

BRIEF REVIEW OF THE LITERATURE

In many countries, attitude surveys have examined the energy consciousness of consumers. Seligman, Darley, and Becker (1978) studied the attitudes of homeowners in their Twin Rivers study. Four factors emerged in a factor analysis of the attitude statements (a total of 55 percent of the variance in consumption was accounted for): personal comfort and health, high effort/low payoff, individual contribution, legitimacy of the energy crisis.

In another factor analysis, Seligman, Kriss, Darley, Fazio, Becker, and Pryor (1979), found the same pattern and an additional factor: belief in science and technology. Consumers who believe in technological solutions to the energy crisis (nuclear

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power, solar or wind energy) tend to reduce their energy use to a lesser degree than those who do not believe in technological solutions. In both studies electricity consumption for summer air conditioning was is the dependent variable.

In other studies, socioeconomic variables are related to self-reported energy use. Newman and Day (1975) compared the energy use of the "poor" with the usage of the "well off"; the energy use of blacks was also examined. De Fronzo and Workev (1979) studied female-headed households' energy use. Cunningham and Joseph (1978) investigated the price responsiveness for energy price increases of low and high income groups.

In few publications is the actual behavior of the household members the focus of research. Attitudes may not be related to actual behavior for several reasons, e.g. consumers do not know what types of behavior contribute to energy saving; "poor" households cannot reduce their energy use any further; consumers may have energy-conscious attitudes but are unable or unwilling to change their behavior. In the study reported here, the focus is on the behavior of household members, an important determinant of household energy consumption.

METHODS

The objective is to investigate the relationship between energy conscious attitudes, energy-related household behavior, and actual use of natural gas in the household. Included are the socioeconomic characteristics of the households, special circumstances during the investigation period, and home characteristics.

Homes Studied

From November 1976 through November 1977, the energy use of 145 households in Vlaardingen, Holy-North (The Netherlands) was monitored. In the area of Holy-North, there are 157 similar homes, 79 having standard thermal insulation of walls and windows, and 78 having superior thermal insulation.

All 157 homes are basically similar in design, except for home insulation, wind orientation, and position of the home with regard to neighbouring homes. The houses are built in rows, attached to each other. A number of houses have only one attached neighbouring house (semi-attached) and three "free" sides. The other houses have two attached neighbouring houses (fully attached) and only two "free" sides. All homes have similar central heating systems using natural gas as a fuel to heat water pumped through radiators in the rooms. The position and wind orientation for homes with standard and superior thermal insulation are similar.

RESULTS

Preliminary Analysis

Attitudes. At the first wave (November, 1976) of this panel study, the respondents answered eight questions on their energy consciousness, price consciousness, attitudes toward home temperature and draughts, and ecological concern. After a principal component analysis of these questions, three factors emerged which explained 62 percent of the total variance. The factors and the proportion of the variance explained by each are: energy consciousness (28.5%), home comfort (17.1%), price consciousness (16.4%). In the remainder of this study, factor scores on these factors, computed for each of the 145 respondents, are used.

Household Behavior. The respondents reported 17 types of energy-related household behaviors. These were factor analyzed and six factors emerged, explaining 58.2 percent of the total variance. The factors and the proportion of the variance explained by each are: bedroom temperature while sleeping (14.3%), home temperatures during absence from home (11.7%), home temperature while at home (9.4%), use of curtains (8.0%), airing rooms (8.0%), and use of bedrooms (6.3%).

In the remainder of the study, factor scores on these six factors, computed for each of the 145 respondents, are used along with the variables, use of hall-door and switching off pilot flame.

Socioeconomic Characteristics. No significant differences were obtained between households occupying homes with standard and with superior thermal insulation.

Energy Use. On four occasions (November, 1976, January, 1977, April, 1977, and November, 1977) the meters for heating gas were read. Table 1 gives the main results for the three periods in the investigation. Households with superior insulation tend to use less natural gas, especially during winter months.

Explaining Household Behavior

Attitudes and Household Behavior. Three attitude variables, obtained from principal component analysis, are employed to predict eight types of household behavior. Table 2 gives the results of eight stepwise multiple regressions. These attitude measures do not predict household behavior very well, except for three situations. Those who prefer higher home temperatures do not lower their thermostats when they are away from home. Price-conscious consumers do close the curtains and possess

TABLE 1

ENERGY CONSUMPTION DURING THREE PERIODS

Energy Consumption	Home With: Standard Insulation	Superior Insulation	All Homes
Average consumption of natural gas (m^3): ($1m^3$ = 1.31 cubic yards)			
Period 1	1015	897	963
Period 2	831	763	797
Period 3	590	508	555
Total	2436	2168	2315
	N = 76	N = 69	

Note: Period 1: November 1976 to January, 1977
Period 2: January, 1977 to April, 1977
Period 3: April, 1977 to November, 1977

longer curtains (to the floor). Energy-conscious consumers tend to use fewer bedrooms.

The attitude-behavior relationships are mainly insignificant. Attitudes predict household behavior up to a maximum of 5 percent. It does not seem to be worthwhile in energy campaigns to change general attitudes because these attitudes are not related to household behavior. Most consumers have rather positive attitudes toward energy-saving and ecological problems but do not behave according to their stated opinions.

Home Evaluations and Special Circumstances. Home evaluations are the household member's evaluation of home comfort, ease of heating the home, evaluation of home insulation, wind evaluation, evaluation of the size of windows, and evaluation of heating problems. Special circumstances include absence during the weekends, absence of wife during the day, the type of former home the household lived in, whether the wife has a full-time, part-time or no paid job outside the home, and shift service of the husband. Home evaluations and special circumstances explain up to 18% of the variance in household behavior. The behavioral factor, "home temperature while at home," is explained particularly well by home evaluations and special circumstances.

Socioeconomic Characteristics. Socioeconomic characteristics of the household have a separate effect on household

TABLE 2

HOUSEHOLD BEHAVIOR EXPLAINED BY ATTITUDES
(beta-weights)

Attitudes	Use of hall-door	Pilot-flame	Bedroom temperature while sleeping (1)	Home temperature during absence (2)	Home temperature while at home (3)	Use of curtains (4)	Airing rooms (5)	Use of bedrooms (6)
Energy consciouness	-.01	-.12	-.02	.01	.04	-.05	.09	-.17*
Home comfort	-.09	-.03	.00	.22**	-.06	-.02	-.04	
Price consciousness	-.05	-.08	-.03	-.07	-.03	.19**	-.10	-.01
Multiple R	.10	.16	.04	.23	.07	.19	.13	.17
R^2	.01	.03	.00	.05	.01	.04	.02	.03

* significant at $p < .05$.
** significant at $p < .01$.

behavior with regard to energy consumption. They explain an average of 9 percent of the variance in household behavior.

Home Characteristics. The characteristics of the home explain an average of 7 percent of the variance in household behavior.

Factors Determining Household Behavior. Combining the effects of a number of these variables explains only an average of 28 percent of the variance in household behavior, a rather low percentage considering that 31 independent variables contribute to this result.

Explaining Energy Use

Household Behavior and Energy Use. Household behavior is represented by the six factors from the principal components analysis and, additionally, the use of the hall-door and the pilot-flame. In order to test which household behavior variables contribute to the explanation of energy use, a stepwise multiple regression was performed, using natural gas consumed as a dependent variable. Table 3 gives the main results. Household behavior variables explain 26 percent of the variance in natural gas use for heating purposes. The major behavioral variables that determine energy use are: home temperature during absence from home, use of pilot-flame, bedroom temperature while sleeping, home temperature while at home (not in Period 3), and the use of the hall-door (not in Period 3).

Recommendations for saving energy, therefore, should emphasize lowering the thermostat when leaving home, turning out the pilot-flame when central heating system is not in use, keeping bedrooms cool while sleeping, not turning the thermostat too high when at home, and closing the hall-door in order to prevent cold draughts from the open front door.

Home Characteristics and Energy Use. Table 4 provides the results of stepwise multiple regression of home characteristics explaining energy use. Home insulation and home attachment (fully attached or semi-attached) are the major factors. Energy use of neighbour contributes only in Periods 1 and 2, the winter periods. Wind orientation contributed depending on the season. The effect of insulation is larger during the winter months.

Twenty-four percent of the variance in energy use is explained by home characteristics only. The 145 homes of this study are very similar in design. It may be expected that for a sample of more dissimilar homes, even a larger percentage of variance in energy use may be explained by a larger set of home characteristics.

Home Characteristics and Household Behavior Explaining Energy Use. Adding home characteristics to the behavioral

TABLE 3

HOUSEHOLD BEHAVIOR EXPLAINING ENERGY USE
(beta-weights)

Household Behavior	Energy Use Period 1 Nov.-Jan.	Period 2 Jan.-Apr.	Period 3 Apr.-Nov.	Total period
House temperature during absence (factor 2)	.25*	.21*	.34*	.30*
Use of pilot flame	.21*	.17*	.25*	.23*
Bedroom temperature while sleeping (factor 1)	.18*	.21*	.15*	.20*
Home temperature while at home (factor 3)	.15*	.17*	.09	.15*
Use of hall-door	.15*	.18*	.09	.15*
Use of curtains (factor 4)	-.07	-.06	.03	-.03
Airing rooms (factor 5)	-.03	-.05	-.06	-.05
Use of bedrooms (factor 6)	-.02	.05	.03	.03
Multiple R	.47	.45	.49	.51
R^2	.22	.21	.24	.26

* significant at $p < .01$

variables will increase the proportion of explained variance in energy use. The explained variance rises to 46 percent, using stepwise multiple regressions.

Families use less energy when they live in insulated homes that are fully attached, with a big energy spender as a neighbour, and a south or southwest wind orientation of the front of the home. They also use less when they lower the thermostat during periods of absence, switch off the pilot-flame, shut the hall-door, have relatively low room temperatures.

Summarizing the indirect influences of home insulation via behavioral change on natural gas consumption, two main effects are clear: people in better insulated homes tend to lower their thermostat while at home and during the night which decreases the energy use. They also air their rooms more frequently and leave the hall-door open more frequently which increases their energy use. These two effects seem to compensate for each other.

TABLE 4

HOME CHARACTERISTICS EXPLAINING ENERGY USE
(beta-weights)

Home Characteristics	Energy Consumption Period 1	Period 2	Period 3	Total
Home insulation	-.44**	-.30**	-.24**	-.35**
Home attachment	-.20**	-.28**	-.24**	-.26**
Energy use of first neighbour	-.27**	-.13**	-.11	-.18**
Wind orientation ENE	.06	.14*	.08	.10
Wind orientation WSW	-.07	-.06	-.16**	-.11
Wind orientation S	-.03	-.09	.02	-.05
Energy use of second neighbour	-.11	-.05	.01	.05
Multiple R	.52	.46	.39	.49
R^2	.27	.21	.16	.24

* significant at $p < .05$
** significant at $p < .01$

SUMMARY OF RESULTS

The results of the multiple regression analyses are given in Table 5 and 6. Table 5 contains the proportions of variance in household behavior explained by energy-related attitudes, socioeconomic characteristics of the households, special circumstances, home characteristics, and combinations of the above independent variables. Overall, an average of 28 percent of the variance in household behavior can be explained by energy-related attitudes, socioeconomic characteristics, special circumstances, and home characteristics. Special circumstances, especially the proportion of time the wife is not at home, account for about 15 percent of the variance. Attitudes, socioeconomic characteristics, and home characteristics explain less variance. It may be expected that personal and household characteristics have a stronger effect on energy behavior for a more diverse sample of households than the households living in Vlaardingen Holy-North. Consequently, the same will be true for the explanation of energy consumption.

TABLE 5

SUMMARY OF VARIABLES EXPLAINING HOUSEHOLD BEHAVIOR

	Min R^2	Max R^2	Average R^2
Attitudes (3 factors)	.00	.05	.02
Socioeconomic Characteristics	.05	.12	.09
Special Circumstances	.07	.18	.15
Home Characteristics	.01	.13	.07
Attitudes + Socioeconomic + Home Characteristics	.15	.23	.19
Attitudes + Socioeconomic + Special Circumstances + Home Characteristics	.24	.36	.28

TABLE 6

SUMMARY OF VARIABLES EXPLAINING ENERGY USE

	R^2 Period 1	R^2 Period 2	R^2 Period 3	R^2 Total Period
Household Behavior (6 + 2 factors)	.22	.21	.24	.26
Home Characteristics	.27	.21	.16	.24
Special Circumstances	.13	.04		.11
Socioeconomic Characteristics				.06
Home Evaluation				.08
Household Behavior + Home Characteristics	.47	.38	.36	.46
Household Behavior + Home Characteristics + Special Circumstances + Socioeconomic Characteristics + Home Evaluation + Attitudes	.59	.46	.46	.58

Table 6 and Figure 1 give the proportions of variance in energy consumption explained by household behavior, home characteristics and home evaluation, special circumstances, and socioeconomic characteristics. Household behavior and home characteristics together explain 46 percent of the variance in energy use over the total period. Adding all variables, 58 percent of the variance in energy use can be explained.

IMPLICATIONS FOR ENERGY CAMPAIGNS

The results of this investigation provide clear indications of the types of household energy conservation campaigns that may be considered. Five types of energy campaigns are feasible.

Changing Attitudes and Household Behavior

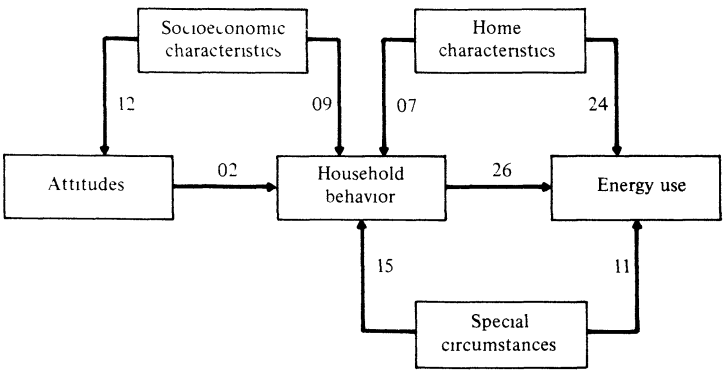
The traditional campaigns for energy conservation are aimed at changing consumer attitudes and consequently household behavior in an energy-saving direction. From this study, only limited support is derived for this type of campaign. The attitude-behavior relationship proved to be weak in that attitudes explain only about 2 percent of the variance in household behavior. Changes in energy-conscious attitudes are not reflected in energy-saving behavior and a decrease in energy consumption. A better attitude measure may explain more variance in household behavior but no dramatic improvement should be expected.

Factors intervening between attitude and behavior are the acceptance of responsibility and the perceived effectiveness as a consumer. Acceptance of responsibility means that the consumer accepts his responsibility of conserving energy and blaming himself and other consumers (and not the industry, the government, or the ecologists) for energy shortages that may occur. Perceived effectiveness includes the notion of personal efficacy in helping to decrease energy consumption and optimism that these efforts will result in positive outcomes. These factors are related to the perception of internal locus of control.

Changing Attitudes Toward Home Improvement

Another type of attitude change campaign may be directed toward changing consumers' attitudes with regard to home improvement such as home insulation, storm doors or windows, and thermostats that set back night time temperature automatically. However, some indications show that the effects of home improvements may be counteracted by household behavior. People living in an insulated home tend to air their rooms more frequently and open the hall-door more frequently. Home improvements and household behavior may both be the consequence of energy-conscious attitudes. However, energy-saving household behavior

Figure 1: Explaining Energy Use in the Home.
Numbers are proportions of explained variance.



will not automatically be positively influenced by home improvements.

Prescription of Home Improvements

Governmental agencies may prescribe, for new or existing homes, certain standards of energy-saving through the use of insulation materials or other energy-saving devices. This strategy is generally followed for new types of automobiles and industrial heating systems. Again, energy-saving types of household behavior as a consequence of home improvements intervene here.

It should be noted that the variation of the houses in this study is rather small. It may be expected that home characteristics would have a stronger effect on energy consumption for a more heterogeneous set of homes.

Feedback Strategies

Strategies employing individual feedback of information include energy consumption information and its costs provided for households on a weekly or monthly basis. Feedback information may induce changes in household behavior in an energy-saving direction. Consumers observing themselves behaving in an energy-conscious way may infer that they must act that way because they have energy-conscious attitudes. According to self-perception theory (Bem 1967), people infer their attitudes from their behavior, instead of inferring their behavior from their attitudes. For example, a small monetary inducement (4A) may create stable attitudinal change. Changed attitudes may result in ecologically concerned behavior, even in areas other than energy consumption in the home, such as recycling behavior, use of phosphate-free detergents, and increased preference for public transportation. Feedback on energy saving increases one's perception of personal effectiveness in helping to solve energy problems, and this reinforces energy-conscious household behavior.

Changing Household Behavior

The fifth type of energy campaign is aimed at directly changing energy-related household behavior. In this type of campaign, changes in household behavior are recommended to consumers. Table 6 showed that the most effective behavioral recommendations are: turn down the thermostat when leaving home, switch off the pilot-flame when the heating system is not in use, have a low bedroom temperature when sleeping, have a rather low room temperature when at home, and keep the hall door closed as much as possible. The last two recommendations are only effective in the winter months (November through April).

SUMMARY AND CONCLUSIONS

Based on the results of this study, the traditional energy campaigns of changing attitudes and, consequently, household behavior and energy consumption, are debatable. However, it can be expected that including measures of acceptance of responsibility and perceived effectiveness as a consumer may improve the attitude-behavior relationship. Consumers may act according to their attitudes when they feel personally responsible for energy problems and perceive that their personal contribution to energy saving is effective.

Home improvement has a strong effect on energy consumption, either in a direct way or through the home evaluation and household behavior as a consequence of home improvement.

The effects of an energy campaign stressing home improvements may be increased by providing behavioral recommendations with regard to energy use. The effects of home insulation, for instance, are counteracted by the tendency for airing rooms and keeping doors open more frequently. Behavioral recommendations should be accompanied by indications of how much energy one saves by changing one's behavior.

From other studies, it appears that individual feedback information approaches are effective in reducing energy consumption. However, the individualistic character of these approaches will make feedback expensive. Changing attitudes into an energy-conscious direction should be accompanied by changing consumer acceptance of responsibility and perceived effectiveness, and behavioral recommendations of how to save energy. Home improvements should also be accompanied by behavioral recommendations. Information in the form of feedback seems to be very effective to maintain new and stable behavioral patterns and to create energy-conscious attitudes.

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